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THE LEHIGH UNIVERSITY (Illustrated) IN THIS NUMBER.

THE LEHIGH QUARTERLY.

Vol. I. APRIL, 1891. No. 2.

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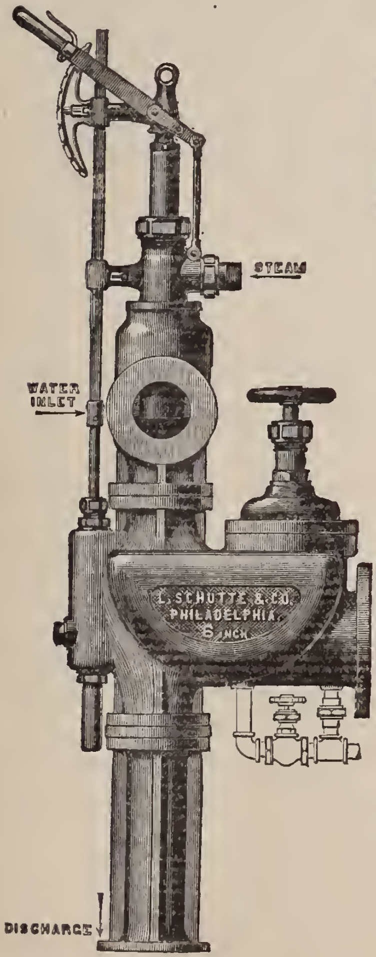

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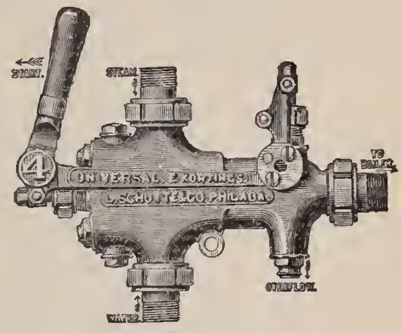

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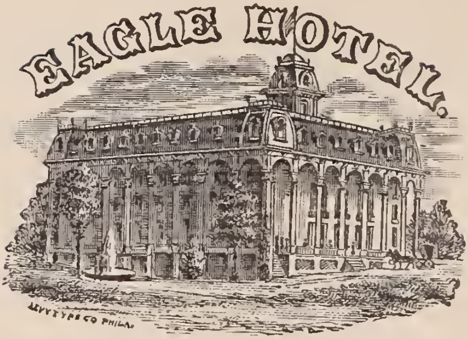
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Vol. I. APRIL, 1891. No. 2.

MATHEMATICS IN EDUCATION.

By Henry Coppée, LL.D., Professor of English Literature, &c.

There are two subjects which agitate at present the minds of persons engaged in education, and which seem at first sight antagonistic, but which, in point of fact, may be entirely harmonized. The first is, the place of mathematics in liberal education; and the second, the place of literary and art culture in technical education. I propose in this paper to consider the first. At the outset I must lay down certain postulates, and answer some preliminary questions in order to be sure of the ground on which we stand.

First, what is education, its logical purpose and its modes? Second, what is mathematics, its various forms and stages, its practical applications? Third, what practical limitations are there that cause modifications of the abstract presentment of this subject? These questions appear at first sight easy to answer, and yet the educational world has been long contending with regard to them, and never more vigorously than now.

I should premise that our discussion concerns the education of the *man of average intelligence*, the machine man, if you will, or the man-machine, *capable* of containing a requisite quantity of all the elementary matter, and *able* to apply, assimilate and use up what he has thus received. Let the distinction be observed that a capable man is receptive of much, (*capere capax*, able to hold.) He can hold much that is put into him, funnel fashion. While an able man, (*habilis*, skilful,) can put what he has received to good and useful account. Many persons confound the meanings of these two words.

Now in point of fact there are so many grades of capability and ability that a complication presents itself at the very outset, and mistaken judgments of men are the consequence. In a college or university the capable intelligence leads. That is what we test. We have less opportunity to test ability there. In life it is the able man we want. When we formulate and tabulate a course for the average man with reference to both these conditions, it would seem that we are holding back with a hand on his throat the superior intelligence, while we are trying to drag forward, by the throat also, the man less endowed by his Maker. In all class instruction this is a difficulty which cannot be easily removed. I am in favor of a high standard, but I think the danger is rather of too high a standard, in our efforts to keep the average man thoroughly up to his work. At West Point, in the higher branches, the men who stand first are permitted to go farther in the science or study than their fellows. This is an example worthy of imitation.

Some curious illustrations occur in this subject of graded intelligence. I recall to mind good fellow-students, intelligent in certain directions, but who dragged painfully along in the mathematics, and came out limping losers at examination periods. I remember a classmate who used to rig up his problems in descriptive geometry with cardboard and string, or in the corner of the room, absolutely making on floor and wall the vertical and horizontal projections of objects suspended like Mohammed's coffin in mid-air. He saw them for an instant, to forget them in the recitation-room; or worse, adding to the jumble in the book the jumble in the corner, he made confusion worse confounded. The man, blind to geometry, was usually strong in analytical work, while the geometer, on the other hand, was apt to be dim in his algebraic investigations.

With this apparent digression we come back to the average man, for whom, and by whose standard, systems of education are prepared. First of the meaning of education. Froebel defines it to be "the complete unfolding of the whole being of man." Joseph

Payne considers its purpose to be "the cultivation of all the native powers exercised according to the laws of being with a view to development and growth." Herbert Spencer declares it to be "that which prepares us for complete living." I might multiply up such apothegms, but it would be to frame our own definition, differing somewhat from them all. Education is the use of instruction in a course of development to suit man to his surroundings. Thus it is conveniently arranged in two parts, the one transcending the other. First, what is called general education, principally rudimentary and elementary, which fits a man to receive all culture. Second, technical or special education, which makes one an expert or a professional man.

Now we reach our second question. The function of mathematics in general or elementary education, or what is called liberal education; a subject which is full of most interesting historical illustrations. From the very beginning of the race until now mathematics appears in every age and among all peoples in the most practical demonstrations. When Cain tilled the earth and Abel kept sheep, and the sons of God saw the daughters of men and found them fair, and began to people this beautiful world,—in their barter, or sale, two things were coōriginal with the race—the measurement of the earth, its surface lines and solid forms, and this was called earth-measure. The Greeks called it the same, from *ge* and *metron* (geometry). And as units and standards of measurement were necessary, they began to use numbers, and they called the science thus created arithmetic (the science of numbers). At first the Greeks meant by arithmetic what we call numeration. Calculation they called *logistike.* Nations that could not count beyond their ten digits were to them doubly barbarians. The most civilized peoples in the world to-day are the best arithmeticians.

But specific and exact numbers soon demanded a more general treatment, and algebra, the science of quantity, came to the rescue, giving formulæ to cover many significates, putting into analysis the entire realm of quantity in its relation to specific quality, arranging under its theorems and problems every case that is governed by *the* mathematical laws. If the use of numbers and quantity was absolutely essential to material and moral progress, analysis and combination, the vehicles of their expression, were also a very great necessity. The seething brains and restless glances of both geometrician and algebraist soon perceived that the two sciences might be combined with the most beneficent results. Every line, surface or solid had not only its picture-writing in geometry, but its ideographic presentation in algebraic equations. *E. g.*, if you can demonstrate by completing the figure that the square on the hypothenuse, c, is equal to the sum of the squares on the other two sides, a and b, (a problem, by the way, claimed to have been demonstrated in China twenty-five hundred years before Christ,) you can formulate and utilize the same analytically by the equation, $a^2+b^2=c^2$. Every geometric figure has its analytical expression. I mean thus only to remind the reader of the great value of analytics in solving the practical problems presented by physical and mechanical science. Leaving with the mere mention the subject of Descriptive Geometry, it would seem so far that nothing was needed to complete the mathematical cycle; but the invention of the Calculus came upon the world as the crown and seal of mathematical science, a powerful engine, to the use of which has become due much of the extended development of physics and mechanics. It is worth a passing observation to note that Aristotle in his "Physics" seems to hint at the Calculus, where he speaks of infinity and continuous quantity. From rectilinear areas the passage was rendered by it easy to all curved boundaries by new formulæ, very short and simple in comparison with those by which Archimedes had determined the ratio of the circumference of a circle to its diameter. This is not the place to make a detailed consideration of the way in which the Differential and Integral Calculus caused science to expand, nor dwell upon the European controversy to which the infinitesimal theory gave rise. The modern student takes his place in the scientific arena, armed with so potent a weapon that he may be compared with the man before Newton's time, as the soldier with a needle gun is contrasted with the knight in his lobster-harness of iron.

From these preliminary remarks let us proceed to consider the place of mathematics in liberal education. If the world moves in all its parts and joints by physical forces according to mathematical laws, then it would seem that among the elementary subjects of education should be the study of those laws, and he who neglects the mathematical course in any and all of its parts is like the man who built his house upon the sand, which the warring elements overthrew.

In answer to the question what part mathematics plays in general education, little more need be said. We live on surfaces, which we cover with lines and angles; we move according to mathematical arrangements; we form part of the cubes of geometry; we are surrounded by an atmosphere of kaleidoscopic figures; we divide our time by arithmetic into hours, days, months, years and calendars; we calculate and count our gains and losses; we project, construct, tabulate and systematize our industries; we group and classify the men and objects around us; we range with rapid motion of thought from the tiniest shell thrown up by a tidal wave to places far beyond the most distant planet of our system, and still further beyond, to the most remote, invisible worlds that revolve in mathematical periphery around the throne of the Eternal himself. While those wonderful laws of Kepler were deduced by mathematics, the humblest forms of social and domestic structure are mathematical also. The far-reaching space between these two extremes is the realm where mathematics rules with tyrannical but beneficent power.

Just here a word should be said of an indirect value of mathematics, *i. e.*, as a trainer of the mind. In the training of the mind clear and exact system is essential, and here mathematics plays no mean part. There have been recognized two kinds of training in the schools; one by those studies that appeal to the imagination, the other by those which simply control the judgment. In fact, these two agree in one. Chief of the first class are language culture and literature; chief of the second, mathematics. On closer inspection it will be found that each subsidizes the other. Of language culture the best results are obtained, not from modern tongues—valuable as they are for other reasons—but from classical languages and especially from the Greek. The subtle manner in which the mind is educated is found in the study of expression, the rhetorical harmony, the adaptation of sound to sense, the latent power of dead words to express living thought.

And yet, to render this culture most useful, we must systematize it in grammars and dictionaries on a mathematical plan. There was an admirable Greek language before there was any grammar, but it was the grammar which threw it open to the world.

On the other hand, mathematics has another and very different function apparently. It takes the unformed mind, the halting and desultory judgment; it holds them and directs them; it teaches them combination by the application of axioms and principles; it transforms the mind into a well-ordered workshop in which each implement and tool hangs on its own nail and is always ready for use. But the difference thus baldly stated between these two kinds of culture would be misunderstood if I did not call attention to the influence of the imagination on mathematical studies themselves. Strange as it may seem, it is true that the imagination leads the judgment. It seems to outstrip the logical steps in the problem. It forecasts conclusions. It bears the astronomer upward in the paths which both observation and analysis are to follow. When, as sometimes occurs, it goes astray in its airy flight, the judgment, which is holding on behind, curbs and controls it, brings it back to the right track, and thus, the one leading, the other restraining, the two at last arrive in company at the long desired goal. Mathematics gives full scope to the imagination, only checking it when it goes astray, and he who can best forecast the end from the beginning is also the most useful and successful mathematician. The most striking and successful illustration of this is found in the imaginative forecast of Sir Isaac Newton, who announced the binomial theorem with entire assurance and belief, and yet who could say, "There it is, I know it to be true, although I have not proved it." I believe that he never actually proved it, but that the proof, wished for and only partially obtained, or—as in the case of Euler—generally demonstrated, was at last produced in full at quite a modern date.

I have spoken thus far of the ordinary curriculum in mathematics as applied to manifold problems in human life and society. Of the later expansions of the field which complete the subject of our third question, I have not time to speak, nor do I consider myself competent to pass judgment upon them, *i. e.*, to include them or to expel them from the logical course.

"Modern Geometry," which after all is not modern, has been especially discussed by M. Chasles, the brother of the better known *litterateur*, Philarète Chasles. The Italians call it Projective Geometry. It treats of polars and receptive polars, of harmonic and unharmonic ratios, and is declared to be an important instrument in the discussion of point and line properties. It has taken its place in the educational course since my day. And so also the "higher algebra" seems not yet to have found its limits. Nor need I speak of "quaternions," except to say that this branch facilitates the geometrical interpretation of imaginary quantities. Carefully investigated by Ampère, it has been set forth for the English world by Sir William Rowan Hamilton. The name *Quaternions* was suggested by the Tetractys of Pythagorus, which he called *the mystic source of all things. Quaternions* as a method discards coördinates and substitutes space in all directions. It has been defined "the quotient of two directed lines in space; or the factor which changes one directed line into another." The method of *Least Squares* is "an application of the theory of probabilities to deducing the most probable result from a series of several measurements or observations of the same quantity."

Last and most puzzling, as well as most interesting, of these modern inquiries into mathematics is what has been called *hyperspace* and non-Euclidian geometry. We all appreciate a point and a line; we multiply intersecting lines and understand a surface; we multiply a surface by a normal line and we have a cube. We are not physically constituted to conceive of any geometric condition in space beyond these forms. We represent them as a, a^2 and a^3. But algebra deals with higher exponents. Can we find a geometrical signification for a^4? This new fancy has led to the hypothesis that, while cubical space is contained within the finite or the conditioned, at the distance of thousands of millions, perhaps millions of millions of miles, far beyond the solar system there is a region where the Euclidian geometry ends, and this is the realm of four dimensions, as our system is the realm of three. To me it seems a strange hallucination, and yet a distinguished professor was so possessed by it that, when this world with its geometry of three dimensions troubled and trammeled him, he used to solace himself with the hope that a better condition of things was in store for him in that distant and future kingdom of hyper-space with its blessed four dimensions. Until this new doctrine is practically established and in working order I leave it out of the course, consigning it to the enthusiastic theorist, who with algebraic symbols can turn a sphere inside out without breaking or stretching its integuments, and who claims that this condition of turned-inside-out-i-tiveness is the real specimen realm of the four dimensions.

To arrive rather abruptly at our conclusion, which has indeed been already postulated, the place of mathematics in education is fundamental. No man can be called liberally educated without it. It should be given in its integrity. But now let me say, while I have no time to discuss the second question which I propounded, that is, how much literary and art culture should be given to technical students? that it presents a most important inquiry, which will be considered at some other time and perhaps by some other hand.

THE LEHIGH UNIVERSITY.

IN the early days the carpenter, who worked only by "scribe rule," the millwright and the surveyor who had learned their trades, and the boss who had worked up through the various stages till he was recognized as competent and reliable, did good work and satisfactory; but with the development of the resources—mineral, agricultural, and manufacturing—the consequent demand for greater means and better methods of transportation, and the sharper competition of increased numbers, there came increasing demands for the better educated architect, engineer, and superintendent.

This led to the founding of scientific or technical schools where young men might learn something of the principles underlying their chosen craft, and thus be more rapidly fitted for its intelligent pursuit, better qualified for oversight of its workmen, and more likely to devise improvements, both mechanical and economical, in it.

Of this class of schools is The Lehigh University, a university as yet only nominally and potentially. But although among the youngest of such institutions in the country, Lehigh has already taken a respectable position among them. Many of its graduates are satisfactorily filling places of trust and responsibility, and the demand for them not infrequently exceeds the supply. It is not uncommon for the President of the University and officers of the Alumni Association to receive urgent calls for Lehigh men and be obliged to respond, "None available."

During the year 1865 the Hon. Asa Packer, of Mauch Chunk, announced to the Bishop of the diocese, the Rt. Rev. William

Bacon Stevens, D.D., his intention to appropriate the sum of $500,000 to the founding of an educational institution in the Lehigh Valley. To this magnificent gift he added one hundred and fifteen acres of land in South Bethlehem, and the Lehigh University was chartered by the Legislature of Pennsylvania in 1866. By his last will Judge Packer secured to the University an endowment of $1,500,000, and to the University Library one of $500,000.

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The institution is under the auspices of the Protestant Episcopal Church, the Bishop of the diocese being, *ex-officio*, the president of the Board of Trustees, but that it is entirely unsectarian in management is evident in that at the present time less than half of the teachers are communicant members of that denomination.

The University was formally opened on Saturday, September 1st, 1886, with two classes, six Sophomores and twenty-five Freshmen.

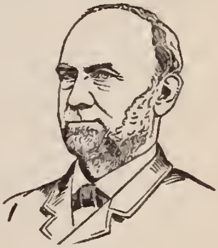
For several years the plan of studies was such that the separation into the different schools took place at the end of the Sophomore year, and the classes were distinguished as the first and second classmen, and junior and senior schoolmen. By gradual changes the point of separation into the various technical courses has been brought to the middle of the first year, and the classical course differs throughout from the others.

HENRY COPPÉE, LL.D.

Of the original faculty, the President, Dr. Coppée, still holds the chair of English Literature, Constitutional and International Law, and Philosophy of History. He resigned the presidency in 1874, but continued to act till the summer of 1875, when the Rev. J. M. Leavitt, D.D., was elected. Dr. Leavitt resigned in the fall of 1879, and on April 1, 1880, Robert A. Lamberton, LL.D., the present executive, assumed the duties of the office. The growth of the institution during the last ten years, *viz.*, students from less than one hundred to over four hundred, instructors from four to twenty-one, and professors from nine to fourteen, is probably sufficient comment on the wisdom of the selection made by the Board of Trustees.

J. M. LEAVITT, D.D.

The other members of the original faculty were Rev. Eliphalet Nott Potter, M.A., Moral Philosophy and Christian Evidences; Charles Mayer Wetherill, Ph.D., M.D., Chemistry; Edwin Wright Morgan, LL.D., Mathematics and Mechanics; Alfred Marshall Mayer, Ph.D., Physics and Astronomy; Wm. Theodore Roepper, Esq., Mineralogy and Geology.



R. A. LAMBERTON, LL.D.

Until 1871 there was no Professor of Engineering proper, the work of that department being done by the Professor of Mathematics and Mechanics, with some help in the field from practicing engineers.

In 1871 the tuition was declared free in all the departments, and a general rearrangement in the teaching force was made. Professor H. B. Herr, who had filled the chair of Mathematics and Mechanics since Professor Morgan's death in 1869, was made Professor of Mathematics and Astronomy.

Major Lorenzo D. Lorain, of the Third U. S. Artillery, having leave of absence for a year, was elected Professor of Physics and Mechanics.

Charles McMillan, C.E., a graduate of Rensselaer Polytechnical Institute, Civil and Mechanical Engineering.

Wm. H. Chandler, Chemistry.

Benjamin W. Frazier, M.A., Mining and Metallurgy.

The Instructors at this time were:

Waldron Shapleigh, A.C., Chemistry.

Wm. A. Lamberton, A.M., Latin and Greek.

Frank L. Clerc, C.E., Mathematics.

S. Ringer, U.J.D., French and German.

Spencer V. Rice, C.E., Graphics and Field Work.

Professor Herr resigned in 1874, and Charles L. Doolittle, C.E., was elected in the spring of 1875. At the close of his year's leave Professor Lorain was succeeded by H. W. Harding, M.A. Professor McMillan resigned in 1875, and was succeeded after some experimenting by Mansfield Merriman, C.E., Ph.D., a graduate of the Sheffield Scientific Institute. In 1877 the chair of Greek and Latin was established, and Mr. Lamberton, the instructor, who was at this time also Instructor in Mathematics, was elected to it. In 1878 Dr. Ringer was elected Assistant Professor of History, and in 1880 the chair of Modern Languages was established, and he was made Professor of Modern Languages and Literature and History. At about this time also the chairs of Greek and Latin were separated, Professor Lamberton retaining the chair of Greek, and Henry C. Johnson, A.M., LL.B., a graduate of Cornell University, was elected Professor of Latin Language and Literature, the Rev. Frederic M. Bird was elected Chaplain and Professor of Psychology, Christian Evidences and Rhetoric, the chairs of Mining and Mechanical Engineering were established, Edward H. Williams, Jr., E.M., A.C., of the class of '75, being appointed to the former, and Joseph F. Klein, D.E., a graduate of the Sheffield Scientific Institute, to the latter. With the establishing of a separate chair of Mining Engineering the course in that school was extended to five years.

Upon the resignations of Professors Lamberton and Johnson, they were succeeded by William A. Robinson, A.M., and Edmund Morris Hyde, A.M., Ph.D., respectively. Professor Lamberton is now Professor of Greek in the University of Pennsylvania, and Professor Johnson is President of the Central High School, Philadelphia.

In 1878 a course of law lectures was given. It was rather an experiment, and although some twenty law students from Easton, Allentown, and Bethlehem matriculated, the response seemed to hardly warrant the expense, and the course was not repeated.

At this time the school of General Literature, which had consisted of a single course, excepting some elective studies in the senior year, and corresponded to the ordinary college academic course, was separated into two, the Classical course and the course of General Science, and in 1883 the latter was further divided into the Latin-Scientific and the course of Science and Letters.

In 1885 a one-year course in Advanced Electricity was begun. In 1888 this was extended to four years, and the school of Electrical Engineering was established. It is at present under the charge of the Professor of Physics, and is one of the most popular schools, being second in point of numbers. Plans for a new Physical Laboratory have been accepted, and this when completed will increase the facilities of the electrical department, which is just now laboring under the disadvantage of cramped quarters and makeshift appliances.

Since the days when the sports were held at Rittersville and the "training" consisted largely in a man's practicing only what he could already do fairly well, there have been great advances along the line of physical culture. Here also Lehigh is placing itself abreast of the older institutions. Its teams may not hold many championships, it may not indeed be represented in all intercollegiate associations; but, though in these incidentals the showing is good, they are only incidentals. Men do not generally send their sons to college to become athletes or acrobats, yet they naturally will prefer a college where, as here, the physical condition of the student is a matter of careful inquiry and its improvement a matter of constant and intelligent effort. Incidentally, an athlete may be here and there developed, but the purpose is the building up of the sound body, without which the sound mind is seriously handicapped in all its efforts. The team work of all kinds and field and indoor sports are of interest, and all Lehigh men are proud of the records made, but they have about as much to do with the efficiency of the department of physical culture as the marks of the men taking the Wilbur prizes have to do with the efficiency of the various schools to which said men happen to belong.

While the growth of the University has been, on the whole, remarkable, yet it is believed to have been natural and healthy. It was, at first, not rapid. As late as 1871 a gentleman who had had some business relations with the founder remarked to a young man of an adjoining State who was casting about for a place to study engineering, that Packer had started some kind of a school down at Bethlehem, and maybe that was about what he was looking for; and although the information was rather vague, it proved to be correct. And in more recent times it was declared with some show of truth that the taking of a second prize by the tug-of-war team at Mott Haven brought Lehigh to the knowledge of more people than had known of its existence before. But while it was not for some years known widely, and even now there may be those to whom it is not the navel of the earth, Lehigh has been always known favorably. Some reasons for this are apparent, and others may be found upon investigation. Declaring the tuition free removed whatever inducement there may be, where revenue is derived from the patrons, to lower the standard either of admission or graduation, or to allow students a nominal attachment to the University so long as fees are paid, even though they are known to lower the tone of the student body both as to morals and diligence. This tends to make the diplomas valuable letters of introduction and testimonials of character. The evident intention on the part of the teaching force to do honest work for the student, not merely to assign him certain tasks and record the percentage of them, "carried to decimals for greater accuracy," that he learns, nor even to bring the sources of useful information within his reach only, but to cultivate in him habits of systematic study and intelligent observation, has doubtless had something to do with the high regard of Lehigh men for Lehigh.

The requirements for admission are, with the exception of the change from four to six books of Geomety in 1877, about what they have always been, and are about the same at Lehigh as at schools of the kind throughout the country, and yet it has somehow come to be thought that the standard here is higher. This may be due to the fact that examinations at Lehigh are not mere initiation ceremonies, but are intended to determine as near as may be whether the applicant will be able to pursue the course of study laid down. Similarly, the final examinations in the various subjects are intended to be examinations in fact. There have, probably, been errors of judgment, by reason of which men who could have done the required work were not admitted, and men with a better knowledge of a subject than the examination showed were not passed in it and therefore not allowed to take up, with their class, the subject next in order, but it is believed that such errors are not frequent. That there have been errors the other way the records show, but the decreasing percentage of failures in the higher classes is noticeable.

The contributions made by Lehigh teachers to the literature of their various specialties are not inconsiderable. Dr. Coppée's Logic and Rhetoric have for years been standards, but probably his greatest work is The Conquest of Spain by the Arab Moors. Professor Doolittle's Practical Astronomy and Professor Merriman's series on Roofs and Bridges have taken high rank as manuals of instruction and practice. Mr. Richards' work on Aluminium, its Properties, Metallurgy, and Alloys, is an important addition to the limited knowledge of what is no doubt destined to be one of the most useful metals, and it has given the author an enviable place as an expert and specialist. Other works, including translations and compilations, have been written both by professors and instructors.

There is now at Lehigh a strong, and it is believed permanent, branch of the Young Men's Christian Association. The difficult task of establishing it, and only those with experience in such work in such a place know of its difficulties, was accomplished by a few of the students themselves. To the men familiar with Lehigh student life, its customs and (borrowed) traditions any time during the first fifteen or twenty years, this is significant.

It means a marked growth in emancipation from that painful, though willing, bondage which a young college, like an upstart nobility, without traditions of its own, is likely to be under to those of others. It means that public sentiment here is beginning to recognize, with the best sentiment everywhere, that the highest type of manhood is Christian, not nominally only but vitally, not merely in assent but in action.

Lehigh is becoming widely known. Twenty-nine States, the District of Columbia, one territory, and eight foreign countries are represented among its students. Naturally Pennsylvania, New York, and New Jersey lead in the order named, and then comes the District of Columbia with a representation of twenty-four. Ohio's delegation of twenty-two can hardly fail to have a President or two concealed somewhere in it. The number of students from Washington, D. C., has always been comparatively large. This was probably due at first to the wide acquaintance of Dr. Coppée, the first President, in military and diplomatic circles, but it is believed that the continued patronage is due to a recognition of the character of the school.

Increased attendance need not, and it is believed does not, affect the thoroughness of the teacher's work as seen from his point of view; his preparation is as painstaking, his presentation of a subject is as clear, and his elucidation of obscure points is as careful with a class of thirty as with one of half that number. But from the true point of view, where results rather than efforts are observed, it is apparent that numbers do impair efficiency, and that the personal hold of the teacher upon the student, which is such a large and important element in all teaching, diminishes beyond a certain limit. Doubtless the limit varies with different teachers, but to even a Mark Hopkins there must have been a limit. In addition to this lessening of the teacher's personal hold, an increase of numbers has also what might be termed a subjective effect upon the student. If only a certain percentage of the recitations can, in general, be called for, his preparation will be more irregular and less thorough and careful than when there is a moral certainty that at every exercise his knowledge of the subject will be a matter of personal inquiry on the part of the teacher.

Continued increase in the number of applicants and the fact that the resources are not affected by increased numbers will doubtless in the near future necessitate a change in the requirements for admission. From the naturally narrowing effect of the technical training demanded to-day, it would seem wiser to increase the number of subjects rather than raise the standard of those already on the list. Up to 1872 there were required "The Elements of Latin Grammar with Rules of Syntax, Four Books of Cæsar's Commentaries" for admission to the general course, and some knowledge of Greek grammar was supposed to be acquired by studying it during the entire first year. The addition of these, with the elements of Botany and Natural History, to the general requirements for admission, would be beneficial not only as so much of information, but the increased mental development due to the additional year of study necessary for their preparation would prove directly beneficial in the subsequent work of every course. An indirect effect would be to practically raise the age of admission by a year, an additional point in its favor.

In a young institution like this without much past the question of its future takes prominence. Lehigh expects to grow. Plans are being devised whose full development will take years to accomplish, especially with the limited means at command. Some institutions are said to be burdened with property, taxable but unproductive, and unavailable for current and general expenses, and with all their wealth, and even because of it, are in great straits. In such cases gifts and legacies may be withheld because of the already great wealth of the institution, when in fact a gift available for immediate use would increase the efficiency of the whole plant out of all proportion to the gift itself. This may not be exactly Lehigh's condition, yet it is feared that its reputed wealth has prevented its receiving from philanthropists that attention which its needs would justify and its character deserves. There is probably no other field outside of missionary lines where an investment would yield better returns.

ARTHUR E. MEAKER.

THE EARLY DAYS OF FOOT-BALL AT LEHIGH.

I was so much more of a spectator than a player in the first games of foot-ball at Lehigh that I felt I could not fairly be accused of writing in self-laudation if I accepted the invitation of the editor of THE QUARTERLY and told something about them.

My position as spectator was not back of the ropes, but behind the rush line to the right of the quarter, where I had an uninterrupted view of the field and absolute leisure, as the captain, though he did not know much, had at least sufficient judgment to always pass the ball to the other half, and I never got it by any chance unless he fumbled it and some one else did not fall on it first. And as our side never got the ball except on those chances regulated by the beneficent fourth down rule, I had plenty of time to study the game and to count the stripes on my jersey and try to keep up with the other side's score. It was not difficult to keep tally of our own.

J. S. Robeson, '86, or "Jake" Robeson, is the father of foot-ball at Lehigh. He had played the game at the Germantown Academy, and it was due to him that it was taken up in South Bethlehem. It was he who induced the Sophomores of the University of Pennsylvania to send their eleven up to play an eleven from '86 on Dec. 8th, 1883, and it was he who captained the 'Varsity team the following year. This game with the '86 eleven of U. of P. was the first game played at Lehigh, and though it was raining at the time, and the grounds were covered with eight inches of mud, over 300 spectators came out to see it played and stood through it until the end, which was a victory for the visitors by a score of 16–0. There was no grass on the athletic grounds then, nothing but rocks, tin cans and a soft quicksand of mud. As the Lehigh Sophomore team had never played before their jackets were as white as when they came from Geisenderfer's shop, where they had been patterned after the only one in the college, one owned by Robeson, and of which we were all very envious. Geisenderfer only charged us seventy-five cents apiece for these jackets, and I hope, if he still lives, that the editor of

THE QUARTERLY will allow this reading notice to stand, as he was a good tailor and gave me long credit. Some of the team had taken their jackets out in the back yard and rubbed them in the dirt in order to give them the appearance of veterans, but the mud of that first game changed them in five minutes into as creditable looking garments as any worn by a Yale captain at the end of the season. It was so muddy that the players' feet actually became fast in it, and "Bish" Howe, who now edits the *Youth's Companion*, the other half-back, called pathetically every few minutes, "Don't pass that ball to me, Jake; I'm stuck in the mud and I can't get out."

And once, I remember, when several of the team sat on Posey's head, (Posey was afterwards captain of the U. of P. 'Varsity,) it went down so far that he was all but smothered, and when it came out it left a beautiful cast of his ears, hair and knitted woolen cap in the mud. The Lehigh men who played in this first game of foot-ball were Robeson, captain; Ruddle, Sayre, Frauenthal, Davis and Adams, forwards; Surls, quarter; Magee and Howe, halves, and Hayward, full-back. The Pennsylvania men who were later prominent on the U. of P. team were Thayer, Posey and Rutter. Referee, Campbell, of Lafayette; umpires, Work, '85, of U. of P., and C. B. Davis, '87, of Lehigh. On the following year the Class of '87 took foot-ball up, and although '86 had made the initiative the '87 men are entitled to the credit of making the game a fixture at Lehigh, and of bringing it to the prominence it now holds.

In those days foot-ball was as different from what it is now as our game was then from the game as played at Yale or Princeton. Even in the best teams of that year (1884,) "interfering" or "guarding" was almost unknown; "bucking the centre," as was done last season, was condemned, and long passes half across the field were the feature of the game. When a man ran with the ball the rest of his team trotted along after him with much curiosity to see as to how far he would get, and signaling was so little understood that a most conspicuous nod for each of the halves was all that was known. This, when compared with Captain Poe's marvelous numerical code of signals, seems almost incredible. No game has advanced as a science so rapidly as has foot-ball, and as simple as it was then the Lehigh men knew even less of it than any other team in the country. When the 'Varsity took the field in 1884 and challenged all comers, Robeson, Knorr, Bradford and C. B. Davis were the only men who had played the game before, and in the first match with Lafayette, which was the first University game played by Lehigh, the other seven men had learnt what little they knew of it in three weeks' practice on the class elevens. We elected Robeson captain, chiefly, I think, on account of his possessing the real foot-ball jacket before mentioned, and practiced daily on the stones and broken bottles of the athletic grounds. Then we prevailed upon the college to pay $52 for eleven brown and white jerseys, and then we thought what we did not know about the game was not worth learning. With this idea we went down to Easton and played the first of those memorable games which year by year became just so many triumphs for Lehigh, until she can now afford to leave Lafayette out of the regular schedule and telegraph her for a substitute game whenever another team fails to fill a date. But it was not that way then. The score of that first game was 52 to 0, and my chief recollections of it consist of personal encounters with the spectators and Easton policemen, who had an instinctive prejudice to Lehigh men which they expressed by kicking them on the head whenever one of them went under the ropes for the ball. We knew so little of the game that only one man had strips on his shoes and the rest of us slid over the worn grass as though we were on roller skates. But on the other hand, we had become so accustomed to the mosaic of our own grounds that falling on turf was like playing on a feather bed to us, while, on the contrary, visiting teams were so alarmed at the prospect of a tumble on our macadamized gridiron that they would rather give up the ball than be downed on it. Those were very primitive days, but we improved ever so slightly, and on the next game with Lafayette scored 4 to their 34, and did somewhat better against Haverford. The class games of that year were much more enjoyable, although nobody ever looked at them. They attracted large crowds, nevertheless, who came to watch the Freshmen and Sophomores fight. These young gentlemen used the class games as an excuse for rushing each other down Shanty Hill and over the ropes or up against the fence, and as for any interest in the two elevens they might have been playing in the dark for all the spectators cared. And it was not at all an unusual thing for the referee to call time in order to allow the players to enjoy the fight going on outside the ropes. The 'Varsity did so badly that first year that we were abused and ridiculed and mocked, and the college almost begrudged us the $52 for the jerseys. It was really a bit ungrateful, as the team did not enjoy being beaten, and added to their chagrin were the bruises and bumps from the stones of the athletic grounds.

The next year's work was a little better, and the third year showed marked change, as these totals of scores will show:

1884,	Lehigh, 16,	Opponents, 181
1885,	" 28,	" 144
1886,	" 90,	" 42

In '87, '88 and '89 foot-ball became the game of all others at Lehigh, and her elevens ranked with the first four teams in the country and it was not because her men cannot play well enough that she is not now in the Championship League, as those of us who have worked to put her there have every reason to know. After leaving Lehigh I met at Johns Hopkins Paul Dashiell, who played with me on the eleven. He says now that I used to abuse him then and even swear at him. If that is so, I take this opportunity of humbly apologizing to the best half-back that Lehigh has ever had, and one who ranks with the first half-dozen that this country has seen. In writing of him as I have had occasion to do at many different times, I have always classed him with Terry, the late Henry C. Lamar, and McClung, and the best authorities on foot-ball, who have no pride in Lehigh as their alma mater, have done the same. Dashiell and Rafferty were undoubtedly the strongest men that Lehigh has given to foot-ball, and although Warriner, Walker, Hutchinson and Porter were strong players and did much for the game, these two were sensational players and ranked with the "stars" of Yale and Princeton. Rafferty was a man who, if he knew what pain was, rather enjoyed it as a sensation than otherwise, and for brute force and endurance was Cowan of Princeton's equal. I remember once, when he broke his collar bone, he refused to leave the field and stood at the ropes watching the game. He stopped training far enough to smoke a cigar, the ashes of which he knocked off nonchalantly on the end of the broken bone where it protruded through his jersey.

Before leaving the old days I want to recall the fact that it was at Lehigh that the V trick was first attempted. It was invented by Jake Robeson, and first tried against Pennsylvania with the success which now always accompanies it. It has become as much a part of the game wherever played as the referee's whistle or the goal posts. Walter Camp, the Yale coach, always credits Lehigh with this trick when he writes. Although I was only asked to speak of the early days of foot-ball, I hope I may suggest for the future that Lehigh's every effort shall be directed towards getting into the Championship League, or, failing in that, to found a new league of the Pennsylvania colleges. Now that she has scored against Princeton, and defeated Pennsylvania and Wesleyan, and accomplished the unprecedented record of winning four games in four days, and, by so doing, the championship of the South, there is no reason why she should not keep in the first rank. Those early scores are very hard to look back upon, but they are forgotten now, and the men who were pioneers then take as keen a pleasure in the good scores to-day as though they made them themselves. At least one of them does. In a late number of *The Burr*, the editor said he would not have the old scores back in the paper again in exchange for all the verses and stories Max or Conway Maur ever wrote for it. I cannot speak for Max, but I can for the other, and I assure the editor of *The Burr* that Conway Maur takes a keener satisfaction in the fact that he scored the first touchdown for Lehigh than in all the verses or short stories he has ever written.

RICHARD HARDING DAVIS.

MECHANICAL ENGINEERING.

Recently THE QUARTERLY Board directed the following queries to several prominent Mechanical Engineers and the answers given by these gentlemen are well worth careful perusal and reflection. Information was requested as follows:

1. What is the present, and probable future demand for Mechanical Engineers?

2. What particular branch of Mechanical Engineering do you think offers the best inducements to a young engineer?

3. What characteristics in a person tend to show a natural aptitude for Mechanical Engineering?

4. What can you say of the attractions which the profession offers to those following it, *i.e.*, mode of life, surroundings, social position?

5. In what way would you advise a young engineer to proceed in obtaining his situation?

Please add all general considerations which may occur to you.

Professor John E. Sweet, president of the Straight Line Engine Company and an eminent authority, writes:

1. As the profession of Mechanical Engineering in this country has grown up in the last few years and is now being extended at a rapid rate, there is no reason to suppose we have reached either the limit of useful knowledge, the limit of demand, or the limit of achievements. The demand ought to increase.

2. Foundry practice, including all kinds of cast materials. The field is perhaps not broad, but there are few in it.

3. A mechanical and business turn of mind, sound physical constitution with energy and disposition to endure work, accept disappointment and failure cheerfully, full of resources and ready to turn defeat into success. Above all, lots of work.

4. None, except to the man who is so constituted that he cannot endure doing anything else. Work and study. Social position will be what the man makes it for himself.

5. Ask for employment; take the lowest position you can content yourself to work at; keep your eyes open and mouth

shut (except to ask for instruction) until you are positive you can say something of real value to some one, where the chances favor their being glad to profit by it.

Mr. Walter C. Kerr, of Westinghouse, Church, Kerr & Co., says:

1. The present demand for Mechanical Engineers, of just the right kind, is large, and the probable future demand will be larger.

2. This is a very difficult question, since each person answering it will be most liable to see more field in the lines with which he is more directly connected than those with which he is less familiar. But, if I had to name two branches, I would say steam and hydraulic engineering, with their various ramifications, offer rather the best inducements.

3. Some of the characteristics which tend to show natural aptitude for Mechanical Engineering are, fondness for machinery in general, inventive talent, clear comprehension of physics, taste for mathematics (though this is by no means essential, for many men of exceptionally good engineering ability have but little of this), clear powers of conception of objects in space (I mean by this that kind of conception which is taught by descriptive geometry; most good engineers possess this to an unusual degree), natural taste for drawing, horse sense.

4. The attractions which the engineering profession offers to those following it are, for educated and cultured men, the equal of the attractions offered by any other profession. The mechanical engineer to-day is recognized, socially, politically, and every other way, the equal of his brother in any so-called learned profession, and it is my opinion that the profession or trade of engineering has practically nothing to do with any question of mode of life, surroundings or social position, these depending wholly upon the personal attainments and qualifications of the man himself.

5. There are so many ways in which a young engineer may proceed to obtain a situation that it is difficult to say which should have the preference; but one way is always good—that is, to pick out the kind of situation that is sure to be satisfactory, and camp out on its front doorstep until it is obtained.

Mr. H. A. Gillis, Master Mechanic of the N. Y., L. E. & W. R. R. Co., writes:

1. In regard to the present and future demand for Mechanical Engineers, I think it is becoming greater each year and I believe that for thorough and reliable engineers there is a large opening.

2. I do not know that I can answer your second question, but I think there is a large opening for men who take up the Railroad branch of work, and I believe that for a young, energetic man it pays as well as anything.

3. In regard to your third question, I may be mistaken, but I do not believe in "natural aptitude" any more than I believe in born mechanics. I have seen too many men who had a natural aptitude for all kinds of trades and professions, and as I look over the list I find that most of them also had a natural appetite for whiskey. It is now my belief that in order for a man to succeed in any profession, he must be studious, sober and industrious, and be endowed with a goodly share of *common* sense.

Success in any profession, except on rare occasions, means hard work, or what is commonly termed hard work, but what will, to any one who is properly interested in the work, soon become a pleasure.

4. I think as to the mode of life, surroundings, and social position, that all these things simply depend on oneself, for I believe that a man may work in the most humble profession and be a gentleman, live like one and surround himself with and associate with the best people. There are always people in every place who consider themselves the best people, and hold what is called the highest social position, and yet whose society can be of no benefit to any one. It has been my experience that it takes a long time to become acquainted and find the *best* people in any town, and also that people generally are very clannish, and that you have to make your choice, and it is far better to wait a year, or even two years, before making friends and acquaintances, and then make them with the right people, than it is to get acquainted sooner and regret that you have done so afterwards. Wherever I have been I have found that the thinking people, or those endowed with the most intelligence and brains, are naturally

drawn together, and I am glad to say that I have always found men of the mechanical profession among those people.

5. In what way would you advise a young engineer to proceed in obtaining his situation? I think that nearly all young men, when they come out of college, are very much inflated with the idea that they know a great deal and should be paid a very large salary for their knowledge. I believe this is all wrong. I think that it is better to choose a branch of the profession which you wish to follow, and then go into some well managed and modern shop or office and work even for a small salary, and get a thorough ground-work in the practice of your profession, and also get a little of the natural conceit taken out of you, and you will not regret it.

There is another thing which I think every young man should take into consideration from a business point of view, if from no other, and that is the value of temperance. I regret to say that some of the brightest and smartest mechanical and civil engineers I know are almost complete failures in consequence of this trouble; and I find that nearly all men who handle large amounts of money prefer to have the services of reliable men, and men whom they know they can depend upon at all times, than to employ smarter but unsteady and unreliable men.

Mr. Robert Allison, proprietor of the Franklin Iron Works, writes:

1. What is the present and probable future demand for mechanical engineers?

In my opinion, based on a general knowlege of the wants of the country, there is a reasonable demand at all times for really good mechanical engineers. The trouble now is to get mechanical engineers with a thorough practical knowledge of construction combined with theory, obtained through a technical education. I find there are many so-called mechanical engineers who are quite ready in calculating strength of materials, proportions, strains, etc., but when tested with some practical question that is met with every day in the construction of machines they are at a loss for an answer. This practical knowledge of construction can only be obtained through years of practice in the actual construction of machines, and in their use.

2. I should say electrical engineering in connection with steam engineering offers the best field at the present time for young engineers. In this connection I would again urge the young engineer to obtain all the practical knowledge possible, so that he would not run the risk of humiliation by having to call on some person with no technical knowledge to help him out, in case of derangement of machinery.

3. A person with mechanical tendencies will show it by his fondness for examining machinery and trying to find out why the machine runs. Boys with this tendency will frequently construct small machines with such tools as they can get together, and their success in this line I think a fair indication of what they will accomplish in mechanical engineering if the opportunity presents itself. The writer remembers, when a boy of thirteen years, living on a farm, constructing a small saw-mill with no other tools than a saw, hatchet and chisel, and setting it up on a small stream running through the meadow. While the mill would do no work the motions were all complete and showed in a marked degree the mechanical tendencies in the mind of the boy.

4. The life of a mechanical engineer does not offer any special attractions over any other profession or business, except in the construction of works of magnitude, which remain as monuments of the genius of the engineer. Taking this view of the case, the attractions offered are special. I need only mention the Brooklyn bridge, which made Rœbling famous; the Eiffel tower in Paris, which has made Eiffel famous the world over. It often happens that the engineer has to live for a time deprived of many of the comforts of life, when constructing works in isolated districts not readily reached, but as a general thing his lines are cast in pleasant places and his social position in the present day is all that can be desired. The recent visit of American engineers to Europe fully demonstrated that fact; they were feasted, toasted and made much of by the best classes of people all over Europe, and nothing was too good for the American engineers.

5. This last question is a rather difficult one to answer. I will just advance one idea that occurs to me. There are many industrial establishments that have no educated engineer connected with them, and whose work is carried on in a slip-shod way,

and which if once shown the advantages derived from the employment of a good mechanical engineer would willingly pay well for his services. Now in order to reach this class of employers, if the young engineer would offer his services at a nominal salary and then go to work and demonstrate his ability to make his services valuable, he would have no difficulty in obtaining a fair salary; another way would be for the young engineer to connect himself with the American Society of Mechanical Engineers, and leave his name with the secretary with his qualifications. The plan is adopted by many. The young engineer becomes acquainted with engineers from all parts of the country, and in this way becomes well known.

SOME NOTES ON PUMPING ENGINES.

Just outside of Bethlehem, in the little village of Friedensville, is what has generally been considered the largest stationary engine in the world.

If we rate the comparative size of engines by the dimensions of their steam cylinders, the Friedensville pumping engine will have to take third rank, but if mass and weight are to be considered, then our neighbor will justly take first position.

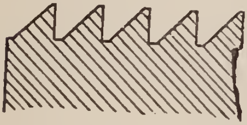
The largest stationary engine known to the writer, if we gauge the size of the cylinder capacity, is one at the Murton Colliery Company, Durham, England. Its dimensions are: Diameter of cylinder, 110 inches; length of stroke, 14 feet; rated horse power, about 1600. This engine pumps from a depth of 1500 feet, and takes 39 boilers to supply the steam.

The next largest is located at Hanover, Germany. Its cylinder is 112 inches in diameter, the length of stroke being 10 feet; this engine was constructed according to the plans of the famous Cornish engineer, John West, now of Reading, Pa., and is very similar to, but not as heavy as the Friedensville engine, which was designed by the same engineer.

Through the courtesy of Superintendent Eudy, of the Friedensville Zinc Company, the writer was recently enabled to obtain much interesting data in regard to the latter engine, some of which are here given.

This engine, which is a single cylinder, condensing, walking-beam engine with a pair of fly-wheels, has a cylinder 110 inches in diameter, and 10 feet length of stroke—it will be noticed that this is only 2 inches less in diameter than the Hanover engine.

The piston rod is 14 inches in diameter, and is connected to the piston by a mammoth nut 24 inches in diameter, 21 inches across flats and 14 inches high. A wrench for this nut was noticed near by which measured 12 feet from centre to end. A duplicate nut kept on hand in case of breakdown showed a peculiarity in regard to the thread, which was what is commonly called half square. Two sweep rods, each 42½ feet in length and 15 inches maximum diameter, weighing about 10½ tons, connect the end of the walking beam with the cranks which give rotary motion to the massive balance wheels. These are 32 feet in diameter and weigh 64 tons each. The walking beam is built up of four main sections bolted in pairs and is 40 feet long, 8 feet deep in the center, and is said to weigh 120 tons. The two bearings for the beam are each 24 inches in diameter by 24 inches long, the brasses are 2 inches thick and are cooled by a stream of water which flows through them and conducts away the heat. The journals were cool when measured, but one of the attendants said they would heat up very quickly if the water were turned off. The number of strokes is nominally 6¼ per minute—that is, 6¼ strokes will keep the mines free from water when once controlled, but if a stoppage occur the water will flow back and the engine will have to be run faster. Ten strokes is not unusual, and is the present speed; 14 has been run, but this is about the maximum at which the engine can be worked. Ten strokes per minute does not appear very fast, yet this gives a piston velocity of 200 feet, which is not so very slow compared with other pumping engines —100 feet per minute is the usual velocity of small pumps.



A battery of 20 boilers supplies the steam, which, according to the gauge, was at a pressure of 50 pounds per square inch. (At normal velocity about 40 pounds pressure is used.)

There are four pump plungers connected with the engine—three 30 inches in diameter and one 22 inches; the discharge, if we disregard leakage and slip, would be 13,280 gallons for ten strokes per minute — over 19,000,000 gallons per day of twenty-four hours.

J. J. FLATHER.

SURVEYING AS A SPECIALTY.

Comparatively few of the young men who enter the technical schools of this country do so with the idea of eventually becoming surveyors. The name has a certain repugnance to them and even excellence in the art seems to them to be too low a mark toward which to aim. They wish to become engineers, and a young graduate engaged in a subordinate position on a railroad location party would have his feelings hurt by being called a surveyor. Nor is this feeling confined to the younger members of the profession; men who have neither designed nor superintended a piece of engineering work in a quarter of a century past and have no expectation of doing so in the future, but whose name is affixed to scores of accurate and well executed plans at the registry of deeds, tell the public that their life work has been only a sort of side line to their real profession when they hang out their sign: Civil Engineer and Surveyor.

There must be reasons for the dislike of the name, and some of them are apparent. The young man, especially if his home be in the country, associates the name with some man of his acquaintance or imagination, who with his knowledge of surveying combines the practice of farming and teaching school, and probably calls himself a "practical surveyor," as did the man who measured several years with a chain before some one pointed out to him the fact that one of its links was missing, and who repudiated the theory that the chain should be horizontal in measuring, because, as he said, by taking measurements along the ground, just as much would be gained in going down hill as was lost in going up.

The young man may be excused for preferring to belong to the same profession as Stephenson, Rœbling and many others whose achievements have spurred his ambition during his college course.

Now, while the desire to practice as a civil engineer as distinguished from a surveyor is laudable enough, it must be remembered that members of the latter profession have accomplished much to the benefit of mankind. The importance of the geodetic survey of the coast of the United States can hardly be overestimated, and involved, perhaps, the surmounting of as many obstacles as any of the great engineering feats of modern times.

Much might also be said about the importance of surveys in accurately locating the metals and minerals in the interior of the country.

It is intended here to simply call attention to this department of civil engineering, the preparation for which has been badly neglected in the past, for while many surveyors in the large cities are men of good technical education, they in most cases have drifted into their present position through force of circumstances, and in youth made no especial effort to prepare themselves for the work they are now doing.

There are some advantages in choosing surveying as a specialty which other branches of engineering do not possess. In the first place, it is generally somewhat easier to start in business for oneself. In the new towns of the South and West young men are wanted constantly, and only ambition and perseverance are needed to make success certain.

After the man has started and built up a practice, if he is industrious and attends strictly to business it is next to impossible for a rival to displace him, for his plans and notes, together with a knowledge of people and property lines gathered only by practice in that locality, give him an immense advantage over the newcomer.

It is an old saying that "a rolling stone gathers no moss," and the civil engineer is no exception to the rule. After months of hard work away from civilization he returns to headquarters in the city and spends his earnings with the freedom and liberality of the sailor in port after a long voyage.

The surveyor is much less apt to have to be continually changing his residence. All his interests are at home and in common with his neighbors, and he has all the advantages arising from social and political friendship, and the knowledge he necessarily has of the value of real estate enables him to invest his money to the best advantage, and he shares all the benefits of residence in an enterprising and prospering place.

In surveying, perhaps more than in the other branches of civil engineering, it will be found that hard work tells, and a man must leave little of importance to his assistants; he must attend personally to work, both in the field and in the office, and, above all, must learn to economize time by working systematically. Before going on the ground with a party he must be sure that he has at hand data sufficient to carry on the work without spending time experimenting. If possible, the deed and plan by which the land was transferred should be examined to see if any natural boundaries or corners are mentioned, and the survey should be started from the one of these which seems to be most likely to be established. If work has been done on adjacent land it should, if possible, be utilized in saving time and labor of measuring one or more lines of present survey. After having collected all available information in the office the party may be taken out and the survey begun from the point before decided upon. Let the assistant read the angles, repeating all of them once or twice to insure accuracy and have the bearings of a number of sides taken as a check.

The surveyor should always be at the head of the party to see that the line is clear and that the measurements are taken carefully, and in keeping notes he should remember that they may be useful at some future time either in the sub-division of this property or on surveys of land adjacent.

In work on small lots, as in the city, one or two assistants will be found to be better than more. Here accurate data are more easily obtained, the only difficulty being the precision with which the work must be done.

Never be in too much haste to finish a piece of work; take all the notes that can possibly be of use, and make a neat and accurate plan to file away, and in this manner save much time in subsequent work. In winter or dull seasons go to the registry of deeds and make tracings of all plans that will possibly be needed when there will be less time to get them. It will also be of advantage to keep a record of real estate transfers, change of names of streets, etc., etc. In regard to the pecuniary benefits, it would be hard to give any definite figures, as they depend largely upon the man and place. It is safe, however, to say that one having the practice of a growing place of 15,000 or 20,000 inhabitants will be able to make more per year than he probably would working at a salary, besides having the satisfaction of being in business for himself, and in the large cities the men who possess the qualifications of a first-rate landscape gardener are making as much money as the best engineers in the country.

Bearing these facts in mind, one should not neglect on account of the name a chance which must offer itself of building up a good practice in surveying for a less promising position in engineering.

JOHN P. BROOKS.

EDITORIALS.

WE announce the election of Mr. Harry T. Morris to THE QUARTERLY Board. This is in pursuance of the plan to have each school represented on THE QUARTERLY.

WE give to our readers in this number the second of our series of opinions by practical men. Our series "Civil Engineering" received praise from one of America's great engineers, and we feel that "Mechanical Engineering" is not less worthy.

THE next number of THE QUARTERLY will be especially valuable. We expect to present to our readers much of interest about our old days.

THE QUARTERLY also announces an article by a practical bridge engineer. It will be of permanent worth and valuable as a practical guide in bridge work.

PRAISE FOR THE QUARTERLY.

IT is especially pleasurable for the editor, who labored with a "thing to be" against odds, and in the face of "it cannot exist," to be the recipient of praise for the object of his trials, "THE QUARTERLY." Yes, it repays for many a struggle to have the effort recognized by our business alumni, who scarce find time to say aught else than "please find enclosed"—and some have neither the time—the money they have—nor disposition to say this much at times. We trust that this issue will receive the same cordial reception and that THE QUARTERLY will ever be so conducted as to fill a place among Lehigh men to the honor of the University and glory of her fair name.

TO CONTRIBUTORS.

THE editors, not having any traditions to refer to in the matter of selecting material for THE QUARTERLY, are somewhat bewildered by the responsibility of starting a tradition for themselves.

As a receptacle for technical articles THE QUARTERLY assumes a very necessary duty here at Lehigh, and on the other hand we think it a not less pressing duty to provide an opportunity for the literary side of the Lehigh student to develop itself.

To this end we shall try to present in each number an equal amount of technical and literary matter. Much of the former will be of such a nature as to interest the general reader.

Literary articles will, we hope, be freely contributed. Permit us to suggest that our contributors adopt this for a maxim: "Have something to write about, and write it clearly." It was suggested to us not long since: "You can buy for a quarter a book full of better stories than a college man can write." And, since other forms of discourse will benefit the writer fully as much and the reader much more, we have concluded that, except in rare instances perhaps, we will do better not to publish stories. We will be grateful, however, for contributions upon any subject with which the writer is familiar and other people are not, for that is what makes a readable article.

OUR INDEX.

THE attention of readers is called to our Index, which contains the subjects of all articles of technical purport contained in all the leading scientific periodicals. The value of such an index as a ready means of locating references to scientific subjects will be readily appreciated by all who are making a study of any technical specialty. The periodicals indexed are all on file in the University Library.

THE ENGINEERING SOCIETY.

THE Engineering Society once more is numbered among the live organizations at Lehigh. Despoiled of its life-blood by college politics and sorely burdened with debt, its last meeting in '90 seemed but a final struggle before an inglorious end.

While there can be but little doubt that even now its growth must be fostered, yet a society that is the oldest in years, that has had on its roll of honorary members such men as the late Franklin B. Gowen, can hardly be in want of friends. The Journal of the Engineering Society has been abandoned. Too narrow in its scope, it had no support and finally became a mere pamphlet. To this journal the debt of the society is due, and it is hoped that ridded of this burden the Society's debt may be discharged.

THE JUNIOR ORATORICAL.

AFTER a lapse of two years the Junior contest was revived by 'Ninety-two. Whatever the careless may say, it must be admitted that the contest is one of the good features of our year, and a much-looked-for event by the majority of the student body. It serves two excellent purposes: that of keeping alive the memory of the day, and of affording to those so inclined an opportunity to appear before the public. Either of these reasons is sufficient to prevent an indifference to the contest that has once broken the list.

The Nine-two contest may be criticised in some parts, but as a whole it compares well with our former ones. Lack of preparation, meaningless gestures, unfeeling delivery as well as essay-orations were noted.

To those who enter the contest next year a word will not be amiss. The prize oration was oratorical. It was short. It was delivered in a natural voice. There were no crude gestures to divert the attention.

OUR LECTURES.

IT is the duty of the Junior Class to see to it that we have our regular lectures on Shakespeare, this term. A petition is all that is needed, and this course, at once popular and instructive, will be continued.

Speaking of our course in Shakespeare brings to mind that a little exertion on the part of a committee could do much towards broadening our present course of lectures. Starting with Dr. Coppée is very well, but there is no reason why others should not be invited to take a part. It matters little whether the subjects be Literature or Science. Many of our professors have in the past manifested a willingness to comply with the request made to them by the various societies, and would undoubtedly favor a course by which they could secure larger audiences.

Invitations might be extended to some of our popular lecturers and in this way broaden the course and lighten the labor of our own professors. Thus could be made up a very complete course and one that would be well received by all. Once established, its very worth would stamp it as a permanent innovation.

WAIFS AND STRAYS.

MIDNIGHT oil seems in some way to be inseparably connected with student life. The faint glimmer of the nocturnal lamp has cast a halo of romance around the student's researches ever since the Benedictine in his cell strained his eyes over an undecipherable manuscript, and Dr. Faustus sat in his vaulted chamber and rehearsed with pardonable pride his repertoire of attainments. Indeed, like the distant star whose light takes years to reach us, the little candle of the midnight toiler may have shone with flickering flame long before we have any record of its presence. For man is a nocturnal animal. The calm, large beauty of night exerts a powerful influence over his brain heated by the whirl of the busy day. There is many a Corinne who sees in the star-lit sky a forest of suggestions that the desert heavens of the day do not afford. If, then, the night is restful and prolific in thought, why is the use of it so eagerly decried? It is not natural, they say, for man to turn the world upside down, to spend the day in bed and the night at his desk. The Freshman, as he departs for the scene of his future conquests, receives from the anxious paternal always the same warning: "Go to bed early, and rise with the lark!" followed by the quotation of that miserable nursery rhyme that has been dinned into the ears of the American youth until it would be an insult to his memory or his education to quote it. The old, old quatrain setting forth the value of seasonable hours in attaining learning, vigor and affluence.

It most certainly is not natural for man, as an animal, to sit up until morn, with rosy fingers, carries out her usual matutinal programme; nor is it natural for man, in his character as an animal, to sit in a chair or to read a book. If he does one, why not the the other? If he so far forgets his precious animal nature as sometimes to remember that he has an intellect and even now and then endeavors to cultivate it, why should he not take the best time for its cultivation? There may be a difference in this respect—there undoubtedly is; but, if some men find that the night quiet most effectually stimulates their brain for vigorous action, let them sit up till noon if they will, and hear no more ceaseless admonition to rise with the lark. Why the lark? Has that small bird such undeniable authority over the universe that all mankind should turn out of bed at its bidding and go through the day so cross and sleepy that one would suppose a lark of a doubtful character had seen him to bed? Is there any more reason for rising with the lark than there is for retiring with the owl? Then let us put the mellifluous biped in his proper sphere and we will wait for the whirr of our alarm clock at seven-thirty before we relinquish the delights of our bed for the doubtful consolation of breakfast.

Here we can't help sighing, "Alas! that it must be seven-thirty." If the beneficent founder of this University had only put some clause in his will forbidding any college exercises to be held before ten o'clock, what a popular place Lehigh would be! Not for lazy men either, but for those who realize that the mind is more active and work more satisfactory from ten in the evening to three than at any other time. With Chapel at ten, or even half-past nine, think of the bliss of the long, drowsy morning hours!

Having awakened at a reasonable hour, we would have a long, delicious doze in that dreamy, rapturous, half-asleep condition, and with "that inward eye, which is the bliss of solitude," we would see hazy visions, all in *couleur de rose*, of happiness, success and fame. Then after leisurely breakfasting we would saunter to Chapel, whether it were compulsory or not, in a devout and receptive frame of mind. Whereas now — the alarm clock's clang, a start, a yawn, and we turn over and are lost until the shadow of an impending evil arouses us again. Then a "sudden rush from the stairway, a sudden raïd from the hall,"—the breakfast table is attacked—another rush, a panting, struggling throng — the dreaded stroke of the impertinent bell, and the punctual custodian slowly and regretfully swings to the door. Another Chapel absence! And so it goes on, until life becomes one dreary waste of Chapel cuts, and we awake some morning to find that, by the kind and thoughtful hand of the powers that be, we are relieved from the necessity and also from the privilege of ever again seeing the interior of the Packer Memorial.

It is not the editor's intention to enter here upon a discussion of the time-worn and travel-stained topic of compulsory Chapel, but he cannot but think that a voluntary service at some reasonable hour, in the dim grandeur of our beautiful church, with plenty of music from our magnificent organ, would not be entirely unattended.

ORIGINAL, AND GOOD.

WHAT IT IS TO LOVE.

To see the whole reflected in one being,
In every quivering throat to hear one voice
To chase from morn to eve a phantom feeling,
To cling to misery with deliberate choice.

To listen for a word that's never spoken,
To tremble with a joy that's never known,
To thirst and hunger for that priceless token,
Round every neck but mine profanely thrown.

To sleep—and pierce in soul the endless distance,
To wake—and find my bliss a lying show,
In short—to lead a vain and curs'd existence
Which yet I'd not for Heaven itself forego.

MISPLACED CONFIDENCE.

A tall, sombre building, whose dark walls conceal
Hosts of maidens, both learned and sweet;
A half-open shutter, a tiny white hand,
A loud-beating heart, as beneath these I stand,
A smile from my "fem-sem" to meet.

The shutter swings wider, my heart louder beats—
How kind of her on me to look!
A second or two of suspense, and behold,
The window is open. In varying fold
The table-cloth waves. 'Twas the cook!

TO A CAMERA FIEND.

A young man who lived in East Cleveland,
Who was up to all crazes and fads,
Bought the best cam'ra he could perceive and
An outfit from lenses to brads.

With nitrate of silver he'd tamper
Till an oxidized Midas was he;
His spirits sustained not a damper
In the study of photography.

To a dark room his heart was cemented
And he made his experiments there,
Till the family thought him demented
And found it quite hard to forbear.

He *took* all his friends and relations
In every conceivable pose;
He disturbed the Case School occupations
In order to "photo" the beaux.

Of bromides and blue-prints were finished
A couple of thousand or more;
His ardor was still undiminished,
Though people avoided his door.

His brain now *developed* so quickly
It expanded to unheard-of size,
He behaved in a way lunaticly
And had a *fixed* stare in his eyes.

His appetite grew quite capricious,
He ate only from *sensitized plates*,
Thought roasted *collodion* delicious
And devoured fricasseed *carbonates*.

To all his kind friends' addresses
He turned a deaf ear, or he froze
His answers with *positive* "yeses"
Or decidedly *negative* "noes."

At length from his vision the *lights* and
The *shades* of this world passed away;
He took *sodium hyposulphite*, and
Now lieth dead under the clay. —A. B. K.

GOSSIP.

WHO are your friends? In college, as elsewhere, a man is known by them, and generally judged by them, but they are of many kinds. There are the friends you want to help, and the friends you like to know, the friends you wait for and walk home with from the club, the friends you call on in their rooms, the friends you play with, smoke with and drink with; the friends of whom you are secretly ashamed.

Your friend is the man who knows you for what you really are, and whom you value for his own true worth; the others are merely pleasant acquaintances, whose company gives you pleasure or amusement, as your mood depends.

I love to go to alumni dinners, not only because I get a good dinner and hear more or less interesting speeches over good wine and cigars, but because it warms the cockles of a man's heart to look around and see the aftermath, the second reaping of a college life — what a pleasure it is to meet a man you really knew and valued and admired. He may have been a wild sort of a devil, that had many faults, and yet there was that in him and between you two that made you friends; it is trust and confidence; you knew just what he would do if placed in such a position; you can count on *him* and he on you. And here you meet him for the first time since the the old careless days when you lay around on the campus and borrowed tobacco from one another. The grasp you give him is different from the hand-shake you gave Heavyweight, the man who stood head of your class when you said, "Well, old man, how are you?" and still different from the greeting bestowed on Mumm, who is still sowing his wild oats, and will probably never stop until he is gathered in with his crop by the old man with the scythe and hour-glass. The grasp you give the man you really know means something: that "Sit down here, old man, and tell me what you have been doing with yourself," means still more; what is more delightful!

Perhaps you have not been separated; then you remember the time when he was so blue and looked so downhearted, and you wonder how any girl can be so hard on such a fine old chap; then when he blurts out all about it you give him lots of good advice, and envy him his happiness, and grumble at yourself for being cut out for an "old bach."

But all this is looking ahead — not so long, however — and is in the future, but "the rule applies," for the present becomes the past before we know it, and we fly by the way-stations in life with hardly a stop, if we keep the track — bar accidents. Four years of college life almost ended, four years of what? — advancement, mistakes, ambitions—fulfilled or otherwise—regrets, perhaps happiness, knowledge gained, chances lost, positions won, tastes formed, impulses given; success, failure or defeat, or merely tossed up at the end as a wave leaves a bit of driftwood on the sand. Our life here is almost "sere and yellow leaf"—what a misapplied quotation—but the little world is nearly over for us, and we have to go out to be judged and given our places in life by a less proscribed society, or else equipped with the arms we have been taught to wield, stand, fight or fall, according to our merits. Some of us may win our spurs at first and fulfil our heart's desire, while others may struggle against odds too much for them; our piece of driftwood, dried by experience and ignited by responsibility, may become a torch, whose light may help others onward in their way, or prove to be valuable material, which, carved and polished, would ornament society.—*Nassau Lit.*

FOR LEHIGH MEN.

A. E. MEAKER

was born February 8, 1848, near Hawleyton, Broome County, N. J. In December, 1863, he enlisted in the 137th Regiment N. Y. Volunteers, which was being recruited after its severe losses at Gettysburg in the summer, and in the Southwest, Lookout Mountain, Chattanooga, etc, in the fall. He joined the regiment at Stevenson, Ala., and served to the close of the war, being in Gray's second division of Hooker's Corps (the 20th). He took part in the siege of Atlanta, happening to be among the first troops entering the city, went "from Atlanta to the sea" and, again, happened to be among the first that entered Savannah on the morning of its evacuation. He was mustered out at Alexandria, Va., in July, 1865, and was among the youngest that carried a musket in the war of the Rebellion, though there were some younger who served as drummers, orderlies, etc. After six years of farm, factory and mill work, and going to school winters, he entered the Lehigh University, having prepared at the private school of S. S. Thomas, Springville, Susquehanna County, Pa., and graduated in 1875. Upon graduation he entered the employ of the Pennsylvania Railroad Company as a draughtsman in the department of bridges and buildings. When this department was abolished he was employed by Wilson Brothers & Co., engineers and architects,who did the work of the old department of bridges and buildings, Mr. J. M. Wilson being the engineer of bridges and buildings for the company. In 1877 he was appointed Instructor in Mathematics at Lehigh, to succeed Mr. Lamberton. In 1890 he published an elementary algebra designed especially for preparatory and high schools.

NOTES.

This column will contain, chiefly, such information in regard to addresses and occupations of Alumni as does not appear in the latest issue of the *Lehigh Register*. Please contribute.

'71. J. N. Barr, M.E. President of the Western Railway Club.

'75. Chas. J. Bechdolt, C.E. Acting Superintendent of the New York Division Pennsylvania Railroad, in absence of Joseph Crawford, Superintendent.

'85. The following is quoted from a paper on the Iron Breaker at Drifton, Pa., by Eckley B. Coxe: "In conclusion I wish to say that I am greatly indebted to my scientific assistant, Mr. John R. Wagner, M.E., for the material aid he has given me in the preparation of this paper. The drawings were all prepared and arranged under his direction, and much of the other work had the advantage of his careful supervision."

'86. F. W. Fink, C.E. City Engineer's office, Cheyenne, Wyoming.

'86. Elec. Geo. H. Neilson. Assistant Supervisor of the Pennsylvania Railroad Division at Altoona.

'88. C. N. Butler, C.E. Address, Room 221, U.S. Patent Office, Washington, D.C.

'88. Elec. W. F. Dean. Manager New York office Thomson-Houston Electric Co., 115 Broadway.

'88. Elec. Wm. H. Hubbard. With the Westinghouse Electric Co., 120 Broadway, New York.

'88. Elec. C. N. Robinson. With the "C and C" Electric Motor Co., 402 Greenwich Street, New York. Address, 303 W. Chelten Avenue, Germantown.

'88. E. B. Wiseman, C.E. Assistant Supervisor on Northern Central Railway, at York, Pa.

'88. Elec. H. C. Young. Superintendent of Lycoming Electric Co.,Williamsport, Pa.

'88. L. R. Zollinger, C.E. Assistant Engineer, Maintenance of Way Department, Middle Division, Pennsylvania Railroad, at Altoona, Pa.

'89. J. S. Kellogg, A.C. Located at Pottsville, with the Edison Electric Co.

'89. A. W. Stockett, C.E., and John Stockett, M.E. Employed on railroad work by the West India Improvement Company, Balaklava, Jamaica.

'90. J. W. Boyd, C.E. Address, Seek, Pa.

'90. J. B. Cullum, A.C. Chemist for the Lickdale Iron Company, Lickdale, Pa.

'90. F. E. Fisher, C.E. Office Engineer, Memphis Little, Rock & Indian Territory Railroad Company. Address, Box 230, Little Rock, Arkansas.

'90. C. A. P. Turner, C.E. With the New York & New England Railroad Company. Address, 180 Summer Street, Boston.

PERIODICAL AND BOOK NOTES.

[A continuation of the list published on page 59 of Vol. I, No. 1, of THE QUARTERLY.]

KEY TO ABBREVIATIONS OF NAMES OF PERIODICALS.

TITLES.	WHERE PUBLISHED.	ABBREVIATIONS.
American Journal of Pharmacy.	Philadelphia.	Am. Jour Phar.
Anthony's Photographic Bulletin.	New York.	Anthony's Phot. Bull.
London, Edinburgh and Dublin Philosophical Magazine.	London.	L., E. & D. Phil. Mag.
Popular Science Monthly.	New York.	Pop. Sci. Month.
Proceedings of the Royal Geographical Society.	London.	Proc. Royal Geog. Soc.
Proceedings of the Royal Society.	London.	Proc. Roy. Soc.

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Alaska and N. W. Br. Columbia. Proc. Roy. Geog. Soc., Feb., p. 65.
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Alternate Current Condensers. L. E. &. D. Phil. Mag., Feb., p. 102.
Aluminium Problem, The. Jour. Frank. Inst., March, p. 189.
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Asteroid, A New. Astrom. Jour. No. 237, p. 167.
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Crimoids, Perisomic Plates of. Am. Jour. Sci., March, p. 247.
Combustion, Luminous and Non-luminous. Jour. Gas Light, March 10, p. 446.
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BOOK REVIEWS.

[Books, or Periodicals, which are to be reviewed or indexed, should be addressed to The Lehigh Quarterly, South Bethlehem, Pa.]

A NEW BASIS FOR CHEMISTRY. By T. Sterry Hunt. Cloth $2.00. (New York: Scientific Publishing Co.)

The following taken from the preface of this book gives an idea of its scope: "Rejecting all hypotheses regarding the constitution of matter as irrelevant to the study of chemistry when rightly understood, and as pertaining to the wholly distinct value of dynamics, the author has attempted to define the limit between the two, and to show that the phenomena of solution, fusion, volatilization, liquefaction, solidification, and crystallization—in a word, all changes of the state—belong to the domain ot chemistry, and that from a right consideration of these some of the most obscure problems of the science become clear." It is indeed an original volume, and has been translated into the French.

SIX CENTURIES OF WORK AND WAGES. BY JAMES E. THOROLD ROGERS, M.P., WITH CHARTS AND APPENDIX BY THE REV. W. D. P. BLISS. INTRODUCTION BY RICHARD T. ELY, PH.D. (THE HUMBOLDT PUBLISHING CO., 28 LAFAYETTE PLACE, NEW YORK.)

An abridgment of a work generally means a weakening of the style and thought. In this little volume, however, we are most agreeably disappointed. It is a condensation of Prof. Rogers' larger work of the same title, and is appropriately introduced by a preface from the pen of Dr. Ely, of the Johns Hopkins University, which introduction alone is sufficient guarantee of the value of what is to follow. Prof. Rogers has been long and favorably known among political economists as a careful and painstaking statistician, and in the subject of wages he has had ample field for his labors. He shows conclusively, what may be a surprise to many, that the fifteenth century and the first quarter of the sixteenth were the golden age of the English laborer. The same is presented graphically by the charts of Mr. Bliss, making the whole book of extreme value to one who wishes to gain more than a superficial knowledge of this subject without spending undue time on a larger volume.

ANALYSIS OF CLAY. BY ALFRED CROSSLEY. CLOTH $1.00. (INDIANAPOLIS: T. A. RANDALL & CO.)

One frequently finds books which contain much, but it is seldom that we have seen a book so carefully arranged to save space. Its contents are exceedingly valuable and this little volume deserves a place among our reference books.

DURABILITY OF BRICK PAVEMENTS. BY IRA O. BAKER. 25 cents. (INDIANAPOLIS: T. A. RANDALL & CO.)

This book is a compilation and presents a series of investigations. No results are presented, as the investigations are incomplete. As almost all literature on brick pavements is fragmentary, it is hoped that so able a man as Prof. Baker may find time to present a standard treatise on the subject.

ARE THE EFFECTS OF USE AND DISUSE INHERITED? AN EXAMINATION OF THE VIEW HELD BY SPENCER AND DARWIN. BY WILLIAM PLATT BALL. (THE HUMBOLDT PUBLISHING COMPANY, 28 LAFAYETTE PLACE, NEW YORK.)

The author of this work has taken it upon himself to coin a word, "use-inheritance," by which he signifies the direct inheritance of the effects of use and disuse in kind. The views of Spencer and Darwin are controverted with skill and not without justice. It is shown that too great reliance has been placed by modern philanthropists on the belief that acquired characters are inherited, whereas, says the author, "general experience teaches that the opposite is true and investigation shows that the apparent exceptions to this rule are probably fallacious." The general get-up of the volume shows the care and taste that has characterized all the publications of this series.

PRACTICAL DYNAMO BUILDING FOR AMATEURS. BY FREDERICK WALKER. PRICE 50 CENTS. (NEW YORK: D. VAN NOSTRAND CO. 1890.)

The book is written for the benefit of "the mighty army of scientific amateurs who would like to construct a practical dynamo" and is an eminently practical treatise, easily comprehensible to any mechanical engineer or artisan worthy of the name. The details of construction are given in full, every part being shown in clear drawings with full dimensions; and the context describes in each case the method of finishing, and, wherever necessary, the peculiarities of the pattern. The chapters on winding are particularly clear and concise. The final pages of the book deal briefly with the use of the dynamo with storage batteries for electro-plating, for electric lighting, etc. The book will be very valuable for those for whom it was written and presents much of the theory of the dynamo-electric current, its generation and management, in such shape as to be easily comprehensible to all those who, wishing to understand the mysteries of electro-generators, are not able to grasp all the technicalities found in most books on the subject of electricity.

TRIPLE-EXPANSION ENGINES AND ENGINE TRIALS. By PROF. OSBORNE REYNOLDS, LL. D., F. R. S., M. INST., C. E. 50 CENTS. (NEW YORK: D. VAN NOSTRAND CO. 1890.

"The expansion of steam in three or more cylinders is now claiming the attention of manufacturers and engineers," and Mr. F. E. Idell has edited here a report of a large number of trials of a triple-expansion engine. The experiments were conducted by Prof. Reynolds, of Owens College, Messrs. Ramsbottom and Robinson and a number of students of the college. The engine consisted of three vertical cylinders, each with its own shaft, fly-wheel and brake dynamometer. These formed three separate engines arranged so as to run with all the shafts coupled or at different speeds. By the use of large receivers, intermediate between the high and medium and the medium and low pressure cylinders, this variation of speeds was made possible. Steam jackets were arranged about the receivers, cylinders and cylinder-heads, so regulated as to be filled with steam at boiler pressure or to be cut off from steam supply as the nature of the test demanded. These features, as well as many other important details, were the result of the special design of the committee with reference to an extended study upon the action of the steam and to facility of measurement of important mechanical actions. A large part of the report is taken up with comprehensive descriptions of various arrangements to effect this purpose and the results of a few representative tests are given in full. The discussion of the paper by other engineers, brings to bear many valuable criticisms upon certain points in question, and much information of worth with regard to steam-jacketing and condensation is elicited.

CHEMICAL AND GEOLOGICAL ESSAYS. By THOMAS STERRY HUNT, LL. D. $2.50. (NEW YORK: SCIENTIFIC PUBLISHING COMPANY. 1891. THIRD EDITION.)

The story of the earth's evolution as found in the rocks is always an intensely fascinating theme for thinking minds. The theory of a molten interior in our planet has long occupied the popular belief because it seemed so abundantly able to account for the natural phenomena of volcanoes, earthquakes and the like, and because it seemed directly consequential to the igneous theory of the earth's formation and to the observed fact of increase of temperature for increase of depth beneath the surface of the earth. In view of the attempts made, especially of late years, to discountenance this theory, Dr. Hunt's book of 489 pages becomes of especial value and interest. As its title indicates, the book is a collection of essays which have been read at different times before the various Scientific Societies of this country and Europe. These essays deal in a general way with the Chemistry of Metamorphic Rocks, of

Limestones, Dolomites and Gypsums, of Natural Waters; on the Theory of Chemical Changes and the Chemistry of the Primeval Earth. The author compares theories on the Origin of Mountains and advances his deductions, as also on the Probable Seat of Volcanic Action. In his essay on the Theory of Igneous Rocks and Volcanoes, he says: "The recent observations of Hopkins show that the melting points of various bodies are greatly and progressively raised by pressure, so that from analogy we may conclude that the interior portions of the earth are, although ignited, solid from great pressure. This conclusion accords with the mathematical deductions of Mr. Hopkins, who from the precession of the equinoxes calculates the solid crust of the earth to have a thickness of 800 or 100 miles.

"Similar investigations by Mr. Hennesy, however, assign 600 miles as the maximum thickness of the crust. The region of liquid fire being thus removed so far from the earth's surface, Mr. Hopkins suggests the existence of lakes or limited basins of molten matter which serve to feed the volcanoes." * * * "The volcanic and igneous phenomena generally ascribed to a fluid nucleus have their seat in the deeply buried layers of aqueous sediments, which, permeated with water and raised to a high temperature, become reduced to a state of more or less complete igneo-aqueous fusion." * * * * "This hypothesis, as we have endeavored to show, is not only completely conformable with what we know of the behavior of aqueous sediments impregnated with water and exposed to a high temperature, but offers a ready explanation of all the phenomena of volcanoes and igneous rocks while avoiding the many difficulties which beset the hypothesis of a nucleous in a state of igneous fluidity."

We would recommend this book to all thoughtful students of the Earth's Crust.

WEDDING'S BASIC BESSEMER PROCESS. TRANSLATED FROM THE GERMAN BY W. B. PHILLIPS, PH.D., AND ERNST PROCHASKA. 8VO. CLOTH, 224 PP. 3 FOLDING PLATES, 70 CUTS IN THE TEXT. 1891. THE SCIENTIFIC PUBLISHING COMPANY, NEW YORK. $3.50.

This work was originally published as a supplementary volume to Wedding's *Die Darstellung des Schmiedbaren Eisen*, (price *M.* 25, 80.) It was published in 1884 and can be had at *M.* 9, — of E. Steigler & Co., New York. Dr. Hermann Wedding is so generally considered an authority in his domain of metallurgy that a criticism on the original work is unnecessary. He deals exclusively with the Bessemer process and does not enter into comparisons with other processes, which, though it would possibly have made the book more interesting, would undoubtedly have made it less direct and concise. Though it is but six years since the book was first published, the relation of the basic open-hearth to the basic Bessemer has radically changed in Germany, so that though the work will always be standard for its scientific worth and for its practical application of chemistry to the process, yet much of the apparatus even at this early day has become somewhat old fashioned.

The translator has, with one or two minor exceptions, given us a clear and well written translation. The paper is good and the arrangement according to the best modern practice. The annotations are not nearly complete, but as far as they go will be valuable to any one reading up the subject. The supplementary chapter on basic open-hearth scarcely represents the latest practice in America. At the Pennsylvania Steel Company's works, where there is now in successful operation, under Mr. McEntee, two of the most improved basic open-hearth furnaces, the charge is pig and scrap, and chromite brick divide the acid roof from the basic bottom.

I also failed to see mention made of the trial made by the above company on the basic Bessemer. Through the kindness of Mr. J. W. Dougherty am able to append a few notes on their handling of the process. The basic lining was made of dolomite containing 1-2 per cent. $Si\,O_2$ and 44-45 per cent. $Mg\,O$, which was calcined in kilns, where it decreased about 50 per cent. in volume, crushed to about the size of peas and mixed with enough coal tar to run well. The ordinary converter was used, into the bottom of which the dolomite was rammed; the tuyer holes were made by ramming the bottom around ⅝-inch rods of iron, which were pulled out when the dolomite lining had been coked by heat. The body of the vessel was lined by ramming dolomite around a "form." Dephosphorization took place during the "after-blow," from 5 to 15 minutes, during which 2 to 4 tests were taken, which were forged, chilled in water at a red heat, and subjected to the cold-bend test under the hammer. When the test bar doubles over without breaking, the steel is about .02 or .03 per cent. of phosphorus. When the phosphorus is not eliminated the fracture will show bright crystals. Though the steel produced was of good quality there was, as in the case of the Pottstown Iron Company, no demand for it in the market, so the process was discontinued. This was nine years ago, and they have been so successful with their open-hearth furnaces since that they will probably never again take up the Bessemer process.

As a whole, the work is one of considerable interest in this age of steel, and is of peculiar value to "iron men" on account of the general way in which the subject is discussed.

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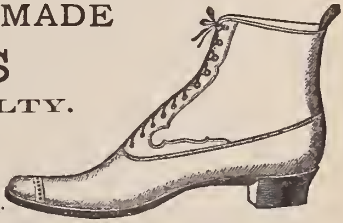

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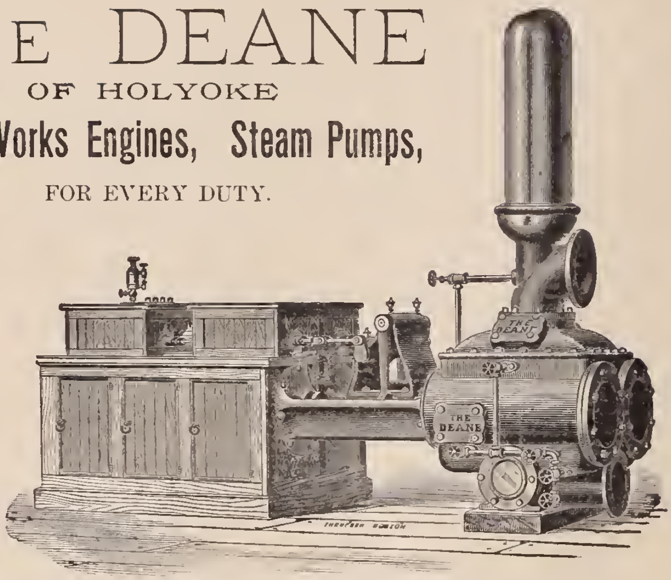

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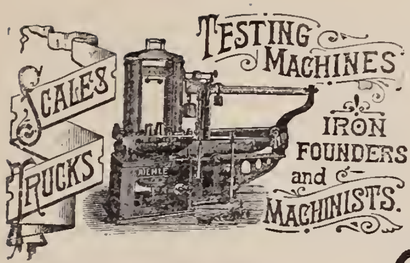

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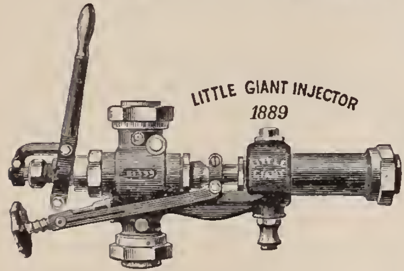

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